Avinashilingam Institute for Home Science and Higher Education for Women

(Deemed to be University under Category 'A' by MHRD, Estd. u/s 3 of UGC Act 1956)
Re-accredited with 'A+' Grade by NAAC. Recognised by UGC Under Section 12B
Coimbatore - 641 043, Tamil Nadu, India

Bachelor's Degree Examination – July 2020
IV Semester

Class : II UG — **Time : 3 Hours**
Major : Botany — **Max. Marks : 100**

18BBOC11 Anatomy and Embryology
Part A — **10X1=10**
Choose the Correct Answer

1. Vascular bundles in a dicot stem are
   a. Open, collateral, exarch — b. Closed, collateral, Endarch
   c. Closed, collateral, exarch — d. Open, collateral, Endarch
2. Intercalary meristem results in
   a. Secondary growth — b. Apical growth
   c. Primary growth — d. None of the above
3. Anomalous secondary growth occurs in
   a. *Dracaena* — b. Ginger
   c. Wheat — d. Sunflower
4. Which exposed wood will decay faster
   a. Sapwood — b. Softwood
   c. Wood with lot of fiber — d. Heartwood
5. In flowering plants meiosis occurs at the time of
   a. Germination of seed — b. Formation of buds
   c. Formation of root primordia — d. Formation of pollen grain
6. Embryo sac is always known as
   a. Microgametophyte — b. Megagametophyte
   c. Microsporangium — d. Megasporangium
7. Monosporic eight nucleated female gametophyte is found in
   a. *Adoxa* — b. Onion
   c. *Fritillaria* — d. *Polygonum*
8. Endosperm of Angiosperms results after fertilization from
   a. Synergids — b. Secondary nucleus
   c. Antipodal cells — d. Egg
9. Dicot embryo consists of
   a. Radicle and Plumule
   b. Radicle, plumule, cotyledons and tegmen
   c. Radicle,plumule, cotyledons and sometime endosperm
   d. Radicle, plumule, cotyledon, tegmen and testa
10. Father of Indian embryology is
    a. BGL Swamy — b. R.N.Kapil
    c. P.Maheswari — d. B.M.Johri

Part B **5 x 6 = 30**

Answer ALL questions

Each answer should not exceed 400 words or two pages

11. a. Differentiate the anatomy of monocot and dicot stem.

(or)

11. b. Describe histogen theory.

12. a. Write short notes on annual rings.

(or)

12. b. Give an account on Cork cambium.

13. a. Draw and explain the *Oenothera* type of embryo sac.

(or)

13. b. Explain the structure of male gametophyte.

14. a. Comment on double fertilization and triple fusion.

(or)

14. b. Describe the development of Nuclear endosperm.

15. a. With diagram explain the development of Asterad type of embryogeny.

(or)

15. b. Discuss the embryo development in *Sagina procumbens.*

Part C **5 x 12=60**

Answer ALL questions

Each answer should not exceed 800 words or four pages

16. a. Give a detailed account on complex tissues.

(or)

16. b. Differentiate T.S. of monocot and dicot leaf with suitable sketches.

17. a. With suitable diagram describe the anatomy of*Boerhaavia* stem

(or)

17. b. Explain the anomalous secondary growth of *Nyctanthas* stem.

18. a. Give an account on various types of Tetrasporic embryosac.

(or)

18. b. Write an essay on development of female gametophyte.

19. a. Describe the structure and development of cellular and helobial endosperms.

(or)

19. b. Give a detailed note on cytology and functions of endosperm.

20. a. With diagram illustrate the development of embryo in *Capsella bursapastoris*.

(or)

20. b. Write a detailed note on monocot embryo development.

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Scheme of Evaluation Set I

Paper Code and Title of the Paper: 18BBOC11, Anatomy and Embryology

Part A

1. d. Open, collateral, Endarch
2. c. Primary growth
3. a. Dracaena
4. a. Sapwood
5. d. Formation of pollen grain
6. b. Megagametophyte
7. d. *Polygonum*
8. b. Secondary nucleus
9. c. Radicle, plumule, cotyledons and sometime endosperm
10. c. P.Maheswari

Part B

11. a. Dicot monocot difference :

Dicot Stems:

1. Stomata have kidney-shaped guard cells.2. The hypodermis is made up of collenchyma which may be green.3. The internal tissues are arranged in concentric layers.4. The ground tissue is differentiated into cortex, endodermis, pericycle, pith, etc.5. The stem is almost always solid.

6. The vascular bundles are arranged in ring around the pith.7. Medullary rays occur in between vascular bundles for radial conduction.8. The vascular bundles are fewer in number and are of similar size.9. The vascular bundles are wedge-shaped in outline.10. No bundle sheath is present on the outside of a vascular bundle.11. The vascular bundles are open due to the presence of cambium in between phloem and xylem.12. Phloem parenchyma is present in the phloem along with other elements.13. The stem shows secondary growth due to the formation of secondary vascular tissues and periderm.14. Vessels are polygonal in outline.15. Vessels are usually arranged in chains or rows. 16. Metaxylem vessels are generally numerous.17. A cavity is not found in the vascular tissues.18. The older vascular tissues stop functioning after some time. They are replaced by younger vascular tissues.19. The stem shows increase in diameter with-age.20. Old stem is covered by a corky bark:

.**Monocot Stems**:

1. Stomata usually possess dumb bell-shaped guard cells.2. The hypodermis is formed of non-green sclerenchyma fibres.3. The concentric arrangement of tissues is absent.4. The ground tissue is a mass of similar cells.5. The stem is generally hollow in the center 6. The vascular bundles are scattered throughout the ground tis7. Medullary rays are absent.8. The vascular bundles are numerous and are of different sizes— smaller towards the outside and larger towards the centre.9. They are oval or rounded in outline.10. A sclerenchymatous bundle sheath is generally present on the outside of each vascular bundle.11. The vascular bundles are closed.12. Phloem parenchyma is absent.13. Secondary growth is usually absent.14. Vessels are oval or rounded.15. Vessels are arranged in a Y-shaped manner.16. Metaxylem vessels are a few in number.17. A cavity containing water is found in vascular bundle by the dissolution or separation of some protoxylem vessels and parenchyma cells lying nearby.18. The first formed vascular tissues continue functioning throughout the life of the plant.19. There is little increase in diameter with age.20. No additional structure is produced for protection of old stem. Persistent leaf bases occur in some.

11.b.Histogen theory

Hanstein in 1868 put forward histogen theory (histogen means tissue builder).According to this theory the tissues of a plant body originate from a mass of meristem where the following three (histogens) can be distinguished:

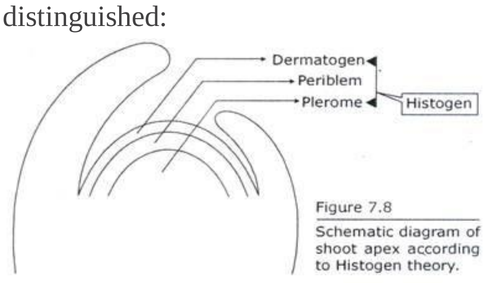


Figure 7.8
Schematic diagram of shoot apex according to Histogen theory.

(a) Dermatogen:

- (In Greek meaning skin). It is the outermost layer of the meristem. It gives rise to epidermises of root and stem.

(b) Periblem:

- This region occurs internal to dermatogen but peripheral to plerome.This histogen is destined to form cortex of root and shoot and inner tissues of leaves. It surrounds plerome.

(c) Plerome:

- This region gives rise to vascular cylinder of stem and root including pith. It is the central core of stem and root and the cells composing this zone are very irregular.This region is enveloped by a variable number of mantle-like layers which are represented by dermatogen and perible. According to Hanstein dermatogen, periblem and plerome arise from independent initials of the apical meristem.Later investigations reveal that the sub-divisions — dermatogen, periblem and plerome have no universal application due to the following two reasons:
- In gymnosperm and angiosperm there exists no clear distinction between periblem and plerome.(ii) The respective roles of the three histogens cannot be demonstrated.The main weakness of Hanstein's concept was to assign specific destinies of histogens. The histogens — dermatogen, periblem and plerome are committal and respectfully give rise to epidermis, cortex and stele. Later this theory was superseded by tunica- corpus theory because the zones are noncommittal.Though histogen theory is rejected it is still regarded as 'classic' due to the fact that Hanstein regarded shoot and root apex as a composite unit consisting of different groups of histogens and the histogens differed fundamentally from each other producing different tissues. It is to note that Hanstein visualized this long before when the concept of gene and DNA was established.This is due to the fact that in zones some genes are activated and others are repressed resulting in the production of different tissues.

12.aannual rings

Fig. 40.44. Annual rings (growth rings)—cut surface of a stem showing annual rings.

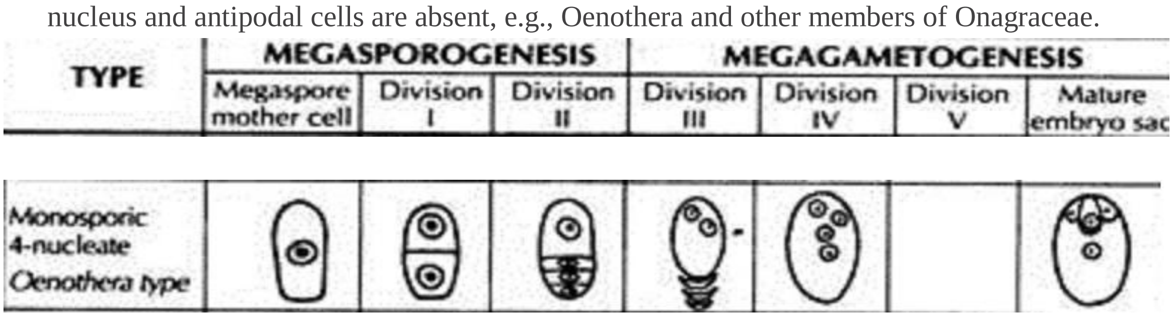
- The secondary xylem in the stems of perennial plants commonly consists of concentric layers, each one of which represents a seasonal increment. In transverse section of the axis, these layers appear as rings, and are called annual rings or growth rings.They are commonly termed as annual rings because in the woody plants of temperate regions and in those of tropical regions where there is an annual alternation of growing and dormant period, each layer represents the growth of one year.The width of growth rings varies greatly and depends upon the rate of the growth of tree. Unfavourable growing seasons produce narrow rings, and favourable seasons wide ones. Annual or growth rings are characteristic of woody plants of temperate climates.Such rings are weakly developed in tropical forms except where there are marked climate changes such as distinct moist and dry seasons. Annuals and herbaceous stems show, naturally, but one layer.In regions with a pronounced cold season, the activity of the cambium takes place only during the spring and summer seasons thus giving rise the growth in diameter of woody plants. The wood of one season is sharply distinct from that of the next season. In spring or summer the cambium is more active and forms a greater number of vessels with wider cavities.
- As the number of leaves increases in the spring season, additional vessels are needed for the transport of sap at that time to supply the increased leaves. In winter or autumn season, however, there is less need of vessels for sap transport, the cambium is less active and gives rise to narrow pitted vessels, tracheids and wood fibres.

12.b. Cork cambium

1. Anatomically it is termed as phellogen.2. The permanent tissues of epidermis, cortex or phloem give rise to phellogen by dedifferentiation.3. Phellogen originates from permanent tissues by dedifferentiation and so it is customary to regard it as secondary meristem. 4. The shape of phellogen may be rectangular or polygonal.5. There exists no such size difference.6. Phellogen and its derivative cells are always arranged in stratified manner.7. The derivative cells of phellogen are nonvascular tissues and occur mostly in extrastelar region.8. The peripheral derivatives of phellogen are phellem.9. The inner derivatives of phellogen are phelloderm.10. Phellogen with peripheral phellem and inner phelloderm together compose periderm of root and stem.11. Periderm forms the protective tissue system of plants

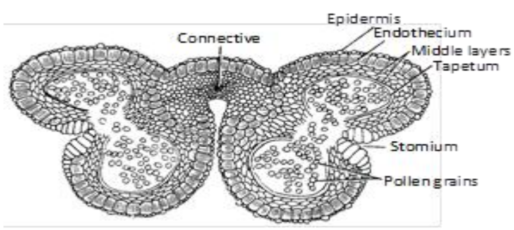
13.aOenothera type embryo sac.

- In this type (like Polygonum type), usual linear tetrad of megaspores are formed, but instead of the innermost one, the outermost megaspore (which is present towards micropyle) remains functional and forms the embryo sac. The functional megaspore undergoes two successive divisions and forms 4 nuclei.All the nuclei remain towards the micropyle. Out of four nuclei, three nuclei form the egg apparatus (egg and two synergids) and the remaining one forms a single polar nucleus. Second polar nucleus and antipodal cells are absent, e.g., Oenothera and other members of Onagraceae.



13.b. Structure of male gametophyte

- **Structure of anther :** The fertile portion of stamens is called anther. Each anther is usually made up of two lobes connected by a *connective*. In turn each anther lobe contains two pollen chambers placed longitudinally. Each pollen chamber represents a *microsporangium* and is filled with a large number of *pollen grains* or *microspores*.



T.S. of mature dithecous anther

The pollen sacs are surrounded by following 4 layers :

(i) **Epidermis :** This is the outermost single layered and protective. In *Arceuthobium*, cells of epidermis develop a fibrous thickening and the epidermis is designated as exothecium.(ii) **Endothecium :** Inner to epidermis, there is a single layer of radially elongated cells. Cells of endothecium develop fibrous thickening (made up of cellulose with a little pectin and lignin) which help in the dehiscence of anther. In between these cells, a few cells without thickening are also present. These thin walled cells collectively form the ***stomium***.(iii) **Middle layer :** Three to four layers of thin walled cells situated just below the endothecium are known as middle layers. Cells of this layer are ephemeral and degenerate to provide nourishment to growing microspore mother cells.(iv) **Tapetum :** This is the innermost layer of the wall. The cells are multinucleate(undergo endopolyploidy) and polyploid. Tapetal cells are nutritive.In these cells the Ubisch bodies are present which help in the ornamentation of microspore walls. A compound sporopollenin is secreted in the exine of microspore wall. According to *Periasamy* and *Swamy* (1966), developmentally the tapetum has dual nature.The tapetum is of two types

(a) Amoeboid or Periplasmodialtapetum.(b) Secretory or Glandular tapetum.

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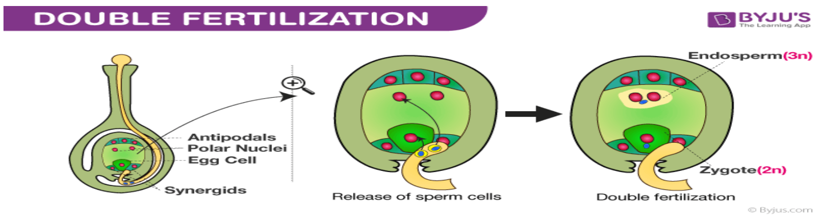
14.a.Double fertilization

Double fertilization is a major characteristic of flowering plants. In this process, two male gametes fuse with one female gamete wherein one male gamete fertilizes the egg to form a zygote, whereas the other fuses with two polar nuclei to form an endosperm.Double fertilization gives stimulus to the plant that results in the development of the ovary into fruit and ovules into seed. The fusion of haploid male and female gametes restores the diploid condition of the plant.Angiosperms are flower-bearing plants and are the most diverse group of terrestrial plants. The flowers form the reproductive part of angiosperms with separate male and female reproductive organs. Each contains gametes – sperm and egg cells respectively.

Pollination helps the pollen grains to reach stigma via style. The two sperm cells enter the ovule-synergid cell. This proceeds to fertilization.In angiosperms, fertilization results in two structures, namely, zygote and endosperm, hence named, double fertilization.Double fertilization is a complex process where out of two sperm cells, one fuses with the egg cell and the other fuses with two polar nuclei which result in a diploid (2n) zygote and a triploid (3n) primary endosperm nucleus (PEN) respectively.Since endosperm is a product

of the fusion of three haploid nuclei, it is called triple fusion. Eventually, the primary endosperm nucleus develops into the primary endosperm cell (PEC) and then into the endosperm.
The zygote becomes an embryo after numerous cell divisions.



Significance of Double Fertilization
Two products are obtained as a result of double fertilization.There are chances of polyembryony and the plant has better chances of survival.Double fertilization gives rise to an endosperm that provides nourishment to the developing embryo.It increases the viability of the seeds of angiosperms.It utilizes both the male gametes produced by the pollen grains.

Trible fusion:

Triple fusion can be defined as the fusion involving two polar nuclei and a sperm nucleus that occurs in double fertilization in a seed plant, giving rise to a triploid nucleus called the primary endosperm nucleus, which later develops into the endosperm.

14.b.Nuclear endosperm

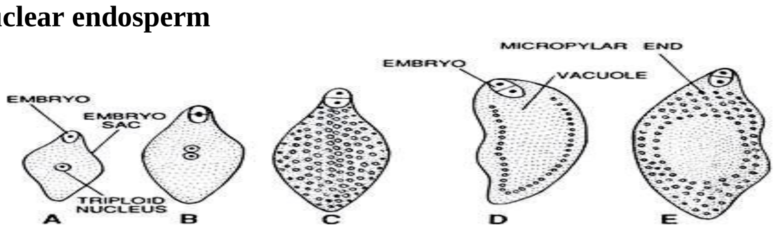


Fig. 46.40. A-E, stages in the development of nuclear type of endosperm.

In this type, the first division and usually several of the following divisions are unaccompanied by wall formation. The nuclei may either remain free or in later stages, they may become separated by walls.As divisions progress, the nuclei are being pushed towards the periphery, thus a large central vacuole is formed. Often the nuclei are especially aggregated at the micropylar and chalazal ends of the sac and form only a thin layer at the sides.Generally the endosperm nuclei in the chalazal part of the embryo sac have been observed to be larger than those in the micropylar end. The number of free nuclear divisions varies in different plants.The development of the endosperm of Cocosnucifera of Palmae deserves special mention. Here the primary endosperm nucleus undergoes a number of free nuclear divisions. When the fruit is about 50 mm long the embryo sac remains filled with a watery fluid or milk containing free nuclei and fine cytoplasmic particles.At a later stage when the fruit becomes about 100 mm in length the liquid shows in addition to free nuclei, several cells each enclosing variable number of nuclei. Gradually these cells and free nuclei set at the periphery of the cavity, and layers of cellular endosperm are formed, and this becomes the coconut meat.On maturity of coconuts the endosperm does not have free nuclei or cells. In Areca nut the development of the endosperm is like that of coconut but the embryo sac cavity is small and it is completely filled up by the growth of the endosperm, and later becomes very hard.Development of helobial type of endosperm in Eremurus. The nuclear type of endosperm formation is the most common type and found in maize, wheat, rice, sunflower, etc.

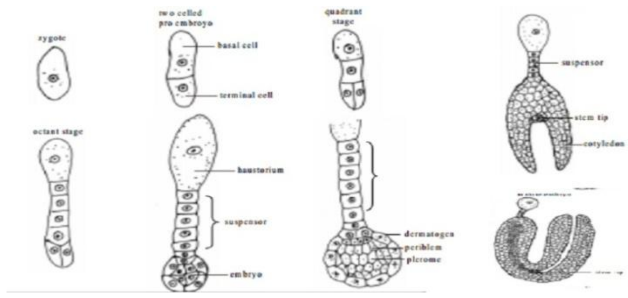
15.aDevelopment of Asterad type of embryogeny :

- Basal and terminal cells play an important role in the development of the embryo.

Asterad Type.**Lactuca saliva** (Jones, 1927) may be used as an illustration of the Asterad type which has been based on the studies of Carano (1915) and Soueges (1920c) on various members of the Compositae. The four-celled proembryo consists of two juxtaposed cells derived from the terminal cell ca and two superposed cells ci and m derived from the basal cell cb. In the follow- ing stage, each of the four cells divides again so that the terminal tier now comprises the quadrant cells q, the middle tier comprises the two juxtaposed cells at m, and ci divides transversely to form the daughter cells n and n' . Thus the upper three tiers of this stage owe their origin to the basal cell cb, and the lowest tier of four cells to the terminal cell ca of the two-celled proembryo. The four cells of the tier q divide to form the octant stage, the walls segmenting the quadrant cells being oriented more or less diagonally ; the two cells of the tier m undergo a vertical division to give rise to four cells lying directly above the octants; n also divides by a vertical wall ; and n' divides by a transverse wall to form o and p . Development of embryo in Lactuca sativa. At the same time tangential walls are laid down in the tiers q and m to cut off an outer layer of dermatogen cells from the inner cells which undergo further divisions to give rise to the periblem and plerome). Regarding further develop- ment, the cell p gives rise to a suspensor consisting of a variable number of cells; o to the root cap and dermatogen of the root; n to the remaining part of the root tip; m to the hypocotyledonary region; and q to the cotyledons and stem tip. Geumurbanum (Soueges, 19236) offers a significant variation from the above scheme in the early demarcation of a special cell called the epiphysis initial. 5 After the two-celled stage) the first wall in ca is markedly oblique, resulting in two unequal cells a and b). Of these, a divides to cut off a wedge-shaped cell e, which is called the epiphysis. At the same time the middle cell m divides vertically and ci divides transversely, so that there are now four tiers of cells in all, designated as q, m, n y 6 For further information on the epiphysis, see Soueges (19346)and n', lying directly above the epiphysis initial e. Of these, q gives rise to the cotyledonary region, m to the hypocotyl, n or one of its derivatives to the hypophysis and a part of the sus- pensor, and n' to the greater portion of the suspensor.

15.bEmbryo development in saginaprocumbans:

Development of dicot embryo



- The zygote divides transversely to form a two-celled proembryo. The cell towards the micropyle is known as the basal cell and the other is known as terminal cell.The basal cell undergoes several transverse divisions to form a long **suspensor.** The terminal cell divides longitudinally twice to form four cells. This four-celled stage of terminal cell is called **quadrant stage.** The four cells of the quadrant stage now divide transversely to form an **octant stage** of eight cells arranged in two tiers of four cells. The lower tier gives rise to the stem tip and cotyledons, while the upper tier is meant for the formation of hypocotyl.This is followed by periclinal division in the octant cells to give rise to eight outer cells, and eight inner cells. The eight outer cells form the **dermatogen,** which divide anticlinally and develop into the **epidermis.** The inner cells form the **periblem** and **plerome**. The cortex develops from the periblem and stele from the plerome. The basal cell divides several times to form a long suspensor of six to ten cells. The lowermost cell of the suspensor nearest to the developing embryo is known as **hypophysis.** The hypophysis, by repeated divisions, gives rise to root cap, epidermis and cortex of the root.

Part C

16.a.**Complex tissues**

- The complex tissues are heterogeneous in nature, being com-posed of different types of cell elements. The latter remain contiguous and form a struc-tural part of the plant, adapted to carry on a specialised function.Xylem and phloem are the complex tissues which constitute the component parts of the vascular bundle. They are also called vascular tissues.

Xylem:

- Xylem is a complex tissue forming a part of the vascular bundle. It is primarily ins-trumental for conduction of water and solutes, and also for mechanical support. Primary xylem originates from the procambium of apical meristem, and secondary xylem from the vascular cambium. As a complex tissue it consists of different types of cells and elements, living and non-living.The tissues composing xylem are tracheids, tracheae or vessels, fibres, called xylem fibres or wood fibres, and parenchyma, referred to as xylem or wood parenchyma.

Tracheids:

- A tracheid is a very much elongate cell occurring along the long axis of the organ. The cells are devoid of protoplast, and hence dead. A tracheid has a fairly large cavity or lumen without any contents and tapering blunt or chisel-like ends.The end walls usually do not uniformly taper in all planes. Tracheids are round or polyhedral in cross-section. They are really the most primitive and fundamental cell- types in xylem from phylogenetic point of view. The wood of ancient vascular plants was exclusively made of tracheids. This is the only type of element found in the fossils of seed-plants.The wall is hard, moderately thick and usually lignified. Secondary walls are depo-sited in different manners, so that the tra-cheids may be annular, spiral, reticulate, scalariform or pitted.
- Tracheids

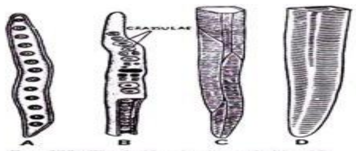


Fig. 538. Tracheids. A. A tracheid with bordered pits. B. A part showing bordered pits with crassulae. C & D. Parts with scalariform thickening.

Xylem Fibres:

- Some fibres remain associated with other elements in the complex tissue, xylem, and they mainly give mechanical support. As previously stated, fibres are very much elongated, usually dead cells with lignified walls.Xylem fibres or wood fibres are mainly of two types: fibre-traeheids andlibiriformfibres which usually intergrade, so much so that it is difficult to draw a line of de-marcation between them.Fibre-tracheids, as already reported, are intermediate forms between typical fibres and tracheids; they possess bordered pits, though the borders are not well-developed. Libiriformfibres ate narrow ones with highly thickened secondary wall.

Xylem Parenchyma:

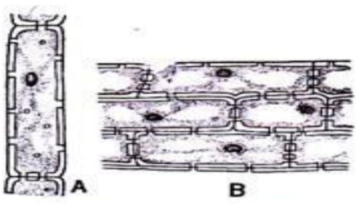


Fig. 541. Xylem Parenchyma. A. Parenchyma. B. Ray cells.

- Living parenchyma is a constituent of xylem of most plants. In primary xylem they remain associated with other elements and derive their origin from the same meristem. In secondary xylem parenchyma occurs in two forms: xylem parenchyma is somewhat elongate cells and lie in vertical series attached end on end; ray parenchyma cells occur in radial transverse series in many woody plants.Parenchyma is abundant in the secondary xylem of most of the plants, excepting a few conifers like Pinus, Taxus and Araucaria. These are the only living cells in xylem.

Phloem:

- The other specialised complex tissue forming a part of the vascular bundle is phloem It is composed of sieve elements, companion cells, parenchyma and some fibres. Sclerotic cells may also be present.Phloem is chiefly instrumental for transloca-tion of organic solutes—the elaborated food materials in solution. The elements of phloem originate from the procambium of apical meristem or the vascular cambium.

Sieve Elements:

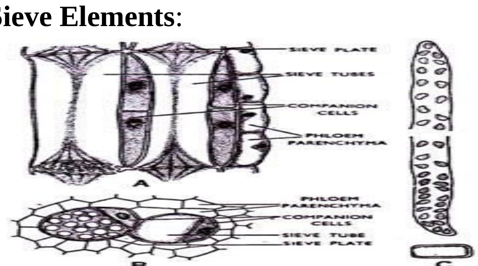


Fig. 542. Sieve elements. A. Sieve tubes in l.s. B. Same in t.s. C. Sieve cell in l.s. and t.s.

- The most important constituents of phloem are the sieve elements, the sieve tubes and sieve cells. From onto-genetic point of view a sieve tube resembles a vessel and a sieve cell a tracheid.
- Sieve tubes are long tube-like bodies formed from a row of cells arranged in longitudinal series where the end-walls are perforated in a sieve-like manner. The perfo-rated end-walls are called the sieve plates, through which cytoplasmic connections are established between adjacent cells.

Sieve tube

- In spite of close ontogenetic resemblance between tracheary elements of xylem and sieve elements of phloem, the latter unlike the former, are living. They originate from the mother cells (Fig 545) which are usually short cylindrical or elongate ones.The mother cell divides longitudinally into two daughter cells, one of which serves as the sieve element and the other one becomes the companion cell, of course in those cases where companion, cells occur. The sieve element undergoes gradual differentiation. It grows in length, cytoplasm gets more and more vacuolated, so that it may have a lining layer of cytoplasm round a large central vacuole.It has been stated that protoplasmic strands pass through the pores of the sieve areas and that the strands remain surrounded by callose.

Companion Cells:

- Companion cells remain associated with the sieve tubes of angiosperms, both ontogenetically and physiologically. These are smaller elongate cells, having dense cytoplasm and prominent nuclei. Starch grains are never present.The companion cells are so firmly attached to the sieve tubes that they cannot be normally separated by maceration.

Parenchyma:

- Besides companion cells and albuminous cells, a good number of parenchyma cells remain associated with sieve elements. These are living cells with cellu-lose walls having primary pit fields. They are mainly concerned with storage of organic food matters. Tannins, crystals and other materials may also be present.

Fibres:

- Sclerenchymatousfibres constitute a part of phloem in a large number of seed plants, though they are rare in pteridophytes and some spermatophytes.They occur both in primary and secondary phloem. These are typical elongated cells having inter-locked ends, lignified walls with simple pits. The fibres of primary phloem are essentially similar to those occurring in cortex and secondary phloem.

16.b**. Difference between monocot and dicot leaf :**

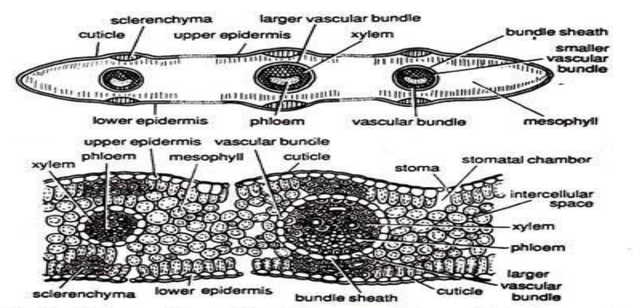


Fig. 174. Triticum : Upper, T.S. leaf (diagrammatic); Lower, T.S. leaf (a part cellular).

Epidermis:

1. Two epidermal layers are present, one each on upper and lower surfaces.2. Uniseriate upper and lower epidermal layers are composed of more or less oval c3. Few big, motor cells or bulliform cells are present in groups here and there in the furrows of upper epidermis.4. Stomata, each consisting of a pore, guard cells and a stomatal chamber, are present on both the epidermal layers.5. A thick cuticle is present on the outer walls of epidermal cells.6. Bulliform cells help folding of leaves.

Mesopbyll:

7. It is not clearly differentiated into palisade and spongy parenchyma but the cells just next to the epidermal layers are a bit longer while the cells of the central mesophyll region are oval and irregularly arranged.8. The cells are filled with many chloroplasts.9. Many intercellular spaces are also present in this region.10. Sub-stomatal chambers of the stomata are also situated in this region.

Vascular System:

11. Many vascular bundles are present. They are arranged in a parallel series.12. The central vascular bundle is largest in size.13. Vascular bundles are conjoint, collateral and closed.14. Each vascular bundle remains surrounded by a double-layered bundle sheath.15. Outer layer of bundle sheath consists of thin-walled cells while the inner layer is made up of thick-walled cells.

16. On the upper as well as lower surfaces of large vascular bundles are present patches of sclerenchyma which are closely associated with the epidermal layers. There is no such association between the sclerenchyma and small vascular bundles.17. Xylem occurs towards the upper surface and phloem towards to lower surface.18. Xylem consists of vessels and tracheids. Sometimes small amount of xylem parenchyma is also present.19. Phloem consists of sieve tubes and companion cells.

Xerophytic Characters:

(i) Thick cuticle on epidermis.(ii) Presence of motor cells.(iii) Sclerenchyma patches are present.(iv) Stomata in furrows.

Identification:

(a) 1. Presence of upper and lower epidermal layers.2. Mesophyll is present.3. Each vascular bundle is surrounded by bundle sheath… Leaf(b) 1. Many vascular bundles are arranged parallaly.2. Absence of cambium.3. Vascular bundles are collateral and closed.4. Stomata on both the surfaces.Isobilateral monocot leaf.

Dicot leaf

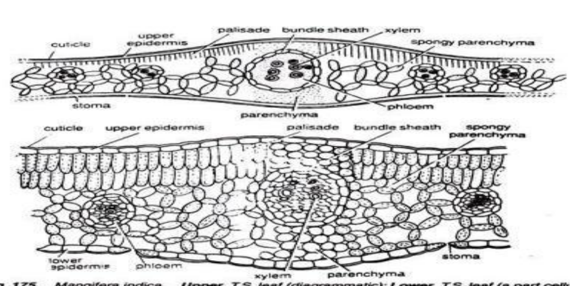


Fig. 175. Mangifera indica. Upper, T.S. leaf (diagrammatic); Lower, T.S. leaf (a part cellular).

Epidermis:

1. An epidermal layer is present on the upper as well as lower surfaces.2. One-celled thick upper and lower epidermal layers consist of barrel-shaped, compactly arranged cells.3. A thick cuticle is present on the outer walls of epidermal cells. Comparatively, thick cuticle is present on the upper epidermis.4. Stomata are present only on the lower epidermis.

Mesophyil:

5. It is clearly differentiated into palisade and spongy parenchyma.6. Palisade lies just inner to the upper epidermis. It is composed of elongated cells arranged in two layers.7. The cells of palisade region are compactly arranged and filled with chloroplasts. At some places the cells are arranged loosely and leave small and big intercellular spaces.8. Palisade cells are arranged at a plane at right angle to the upper epidermis, and the chloroplasts in them are arranged along their radial walls.9. Parenchymatous cells are present above and below the large vascular bundles. These cells interrupt the palisade layers and are said to be the extensions of the bundle sheath.

10. Spongy parenchyma region is present just below the palisade and extends upto the lower epidermis.11. The cells of spongy parenchyma are loosely arranged, filled with many chloroplasts and leave big intercellular spaces.

Vascular Region:

12. Many large and small vascular bundles are present.13. Vascular bundles are conjoint, collateral and closed.14. Each vascular bundle is surrounded by a bundle sheath.15. Bundle sheath is parenchymatous and in case of large bundles it extends upto the epidermis with the help of thin-walled parenchymatous cells.16. The xylem is present towards the upper epidermis and consists of vessels and xylem parenchyma. Protoxylem is present towards upper epidermis while the metaxylem is present towards the lower epidermis.17. Phloem is situated is present towards the lower epidermis and consists of sieve tubes, companion cells and phloem parenchyma.

17.aAnatomy of Boerhavia:

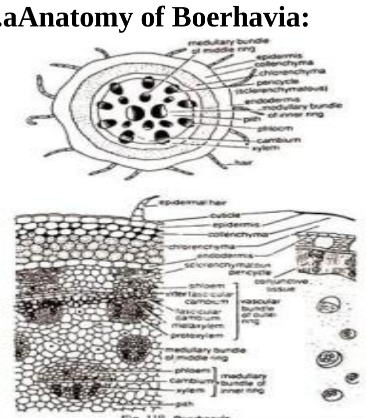


Fig. 119. *Boerhaavia*
Upper – T. S. stem (Diagrammatic); Lower Left – A part of young stem (magnified); Lower Right – A magnified part of old stem.

Epidermis:

1. Single layered epidermis consists of small, radially elongated cells.2. Multicellular epidermal hairs arise from some cells.3. A thick cuticle is present on the epidermis.4. Some stomata are also present.

Cortex:

5. It is well differentiated and consists of few layered collenchymatous hypodermis followed by chlorenchyma.6. Collenchyma is 3 to 4 cells deep, but generally near stomata it is only one layered.7. Chlorenchyma is present inner to collenchyma in the form of 3 to 7 layers.8. Chlorenchymatous cells are thin walled, oval, full of chloroplasts and enclose many intercellular spaces.9. Endodermis is clearly developed and made up of many, tubular, thick-walled cells.

Pericycle:

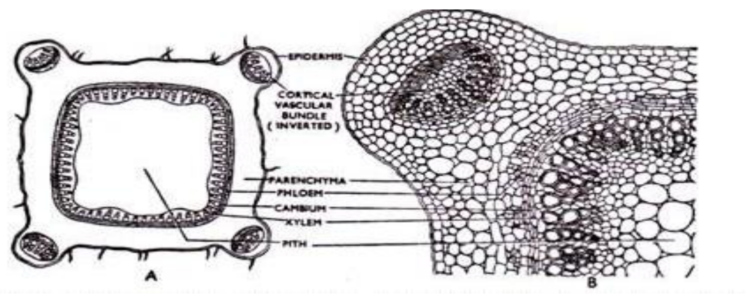
10. Inner to the endodermis is present parenchymatouspericycle but at some places it is represented by isolated patches of sclerenchyma.

Vascular System:

11. Vascular bundles are present in three rings. In the innermost ring are present two large bundles; in the middle ring the number ranges from 6 to 14 while the outermost ring consists of 15 to 20 vascular bundles.12. Vascular bundles of innermost and middle rings are medullary bundles.13. Vascular bundles are conjoint, collateral and endarch.14. Two vascular bundles of the innermost ring arc large, oval and lie opposite to each other with their xylem facing towards centre and phloem outwards.15. Middle ring consists of 6-14 small vascular bundles.16. Vascular bundles of inner and middle rings may show a little secondary growth.17. Phloem consists of sieve tubes, companion cells and phloem parenchyma while the xylem consists of vessels, tracheids and xylem parenchyma.18. Outermost ring of the vascular bundles contain inter-fascicular cambium which is absent in other two rings.19. Cambium develops secondarily from the pericycle and becomes active. It cuts secondary phloem towards outer side and secondary xylem towards inner side. Due to these changes the primary phloem becomes crushed and present next to pericycle.

Primary xylem is situated near the pith.20. Interfascicular cambium also soon becomes active and cuts internally the row of cells which become thick walled and lignified and are known as conjunctive tissue.
Pith:
21. It is well developed, parenchymatous and present in the centre.

17.bAnamolous secondary growth of Nyctanthus



- In the stem of Nyctanthes of the family Oleaceae apart from normal vascular bundles occurring in more or less a ring, there are four cortical bundles at the ridged portions of the stem. These bundles are inverted. They are obviously leaf trace bundles.The central vascular bundles are rather compact collateral open ones with intervening patches of parenchyma in form of rays.In many dicotyledons the roots become fleshy and serve as organs of storage. Anomalies are often noticed in these organs which develop considerable storage parenchyma. Moreover, due to anomalous cambial activities the conducting elements are multiplied and suitably arranged for movement of food materials.Massive development of storage parenchyma is noticed in many cases in the region of cortex or secondary phloem.Many fleshy roots exhibit a notable deviation from the normal structure in the comparatively poor development of woody tissues.In the fusiform roots of radish which are formed by the association of the hypocotyl with the base of the tap root, the storage tissue mainly originates by proliferation of parenchyma in the pith, if pith is present and from the secondary xylem—the xylem parenchyma and xylem rays developing massive storage parenchyma.The vascular elements with some fibres remain arranged in concentric rings here. The fleshy nature of the conical root of carrot (Daucuscarota of family Umbelliferae) is also due to massive development of storage parenchyma in the phloem and xylem.

18.a**Various types of tetrasporicembryosac**

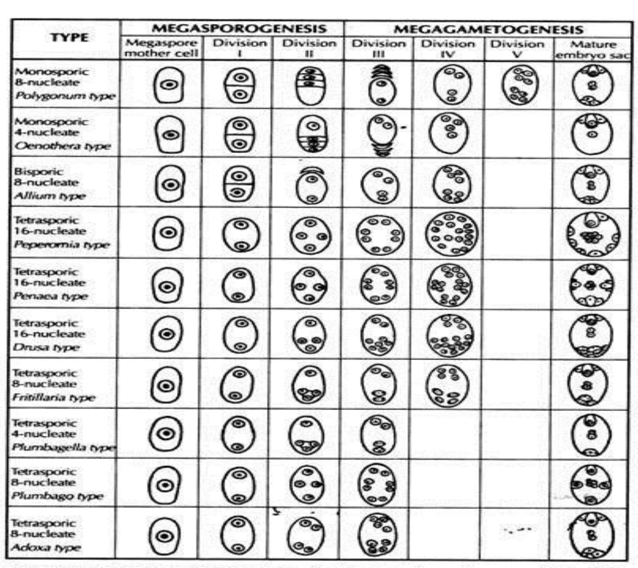


Fig. 3.8 : Development of different types of embryo sac in angiosperms (*after* Maheshwari)
[Micropyle above in all illustrations]

Peperomia type:

- The megaspore mother nucleus undergoes meiotic division and forms four nuclei which remain crosswise in the embryo sac without any wall. All the nuclei undergo two successive divisions and form 16 nuclei which remain dispersed inside the sac. Later on, out of 16 nuclei, egg and one synergid remain at the micropylar end, six antipodal cells towards the chalazal end, and the rest eight at the centre forming polar nuclei, e.g., Peperomia of Piperaceae etc.

4. Penaea type:

- Like Peperomia type, 16 nuclei are formed, those remain crosswise in the embryo sac. Later on, the nuclei are dis-tributed in a different manner. The egg and two synergids remain at the micropylar end, three nuclei at the chalazal end, and four at the centre and three each on the two side walls, e.g., Penaea of Penaeaceae**.**

5. Drusa type:

- Like Peperomia type, initially four megaspores are formed, these are distri-buted in different ways. One megaspore remains towards the micropyle, and the rest three at the chalazal end.All the nuclei undergo two divisions and form 16 nuclei, out of which four nuclei remain towards the micropyle and the rest twelve at the chalazal end. In the mature embryo sac, egg and two synergids remain towards the micropyle, two (one from each pole) at the centre and the rest eleven at the chalazal end, e.g., Drusaoppositifolia of Apiaceae**.**

6. Fritillaria type:

- Like Drusa type, out of four nuclei formed, one nucleus remains towards the micropyle, and the rest three at the chalazal end. The chalazal nuclei fused together and form 3n nucleus. Both the cells thus undergo one mitotic division and again form a tetrasporic stage. Out of four nuclei, two remain at each pole.All the nuclei then undergo mitotic division and form eight nuclei.

Plumbagella type:

- It is like Fritillaria type which forms 1st and 2nd tetrasporic stage with two haploid nuclei at the micropyle and two triploid nuclei at the chalazal end of the embryo sac.

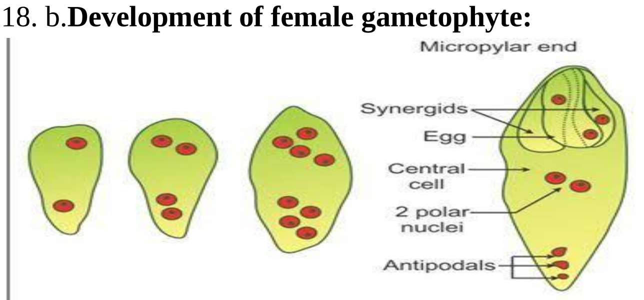
8. Plumbago type:

- It is like Penaea type where firstly four nuclei are formed followed by eight nucleated embryo sac. The two nuclei at each side (four sides) remain crosswise. Later on, four nuclei, one from each side, become aggregated in the centre.

9. Adoxa type:

- In this type, the megaspore mother nucleus divides meiotically into four nuclei arranged two at each end. Both the nuclei — further undergo mitotic division and thus eight nuclei are formed.

18. b.**Development of female gametophyte:**

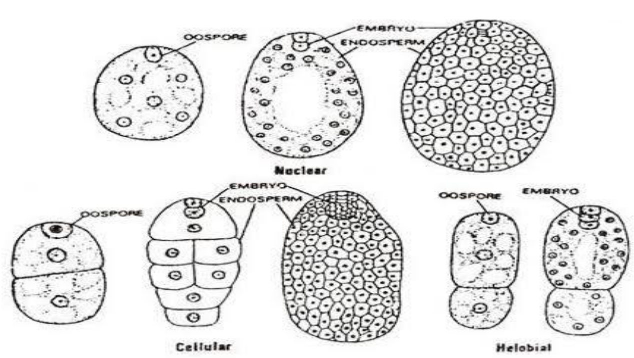


Development of Female Gametophyte

- The functional megaspore is the first cell of the female gametophyte.The cell enlarges and undergoes three free nuclear mitotic divisions. The first division produces two nucleated embryo sac. These two nuclei divide twice forming four nucleate and then eight nucleate structure.One nucleus from each side moves to the middle of the embryo sac. They are called polar nuclei.The remaining three nuclei form cells at the two ends, three celled egg apparatus at the micropylar end and three antipodal cells at the chalazal end.The middle binucleate structure organises itself into a central cell.The female gametophyte in angiosperms is called the embryo sac. It is a 7-celled and 8-nucleated structure.

19.a) Structure and development of cellular and helobial endosperms:

Cellular Type



Types of endosperm.

- In this type, the first and most of the following divisions are accompanied by wall formation and thus the sac is divided into several chambers, some of which may contain more than one nucleus. The first wall is usually transverse but sometimes vertical or oblique, and in some other cases, the plane of division is not constant.On the basis of the orientation of walls following the first two or three divisions, this type of endosperm has been further divided into several subtypes.

Helobial Type:

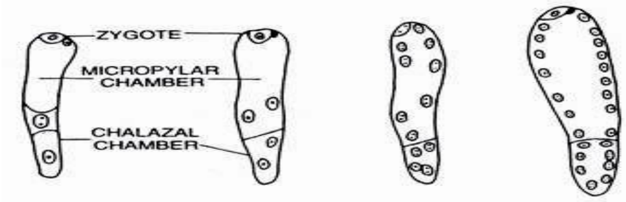


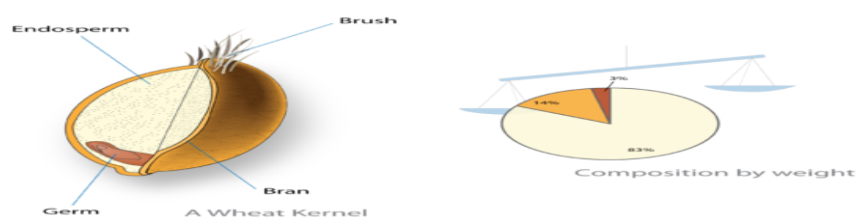
Fig. 46.41. Development of helobial type of endosperm in *Eremurus.*

- This type is frequently found in the members of the order Helobiales. This type is intermediate between the nuclear and the cellular types. In this type the first division is followed by a transverse wall resulting in a micropylar and chalazal chamber. Further divisions are generally free nuclear and may be formed by the micropylar chamber only.
- Eremurus is an example of a typical Helobial endosperm. Here the primary endosperm nucleus divides tranversely forming two chambers, a large micropylar and a small chalazal. Free nuclear divisions occur in both but are more rapid in micropylar chamber.
- Thus, when four nuclei are formed in the chalazal chamber, eight nuclei are produced in the micropylar chamber.

19.bcytology and functions of endosperm

Function of endosperm:

- Endosperm is mainly composed of nutrients such as starch, proteins or oils. These nutrients are used for many purposes.During seed germination – The nutrients in the endosperm are used in the development of embryo during germination. During germination, seeds are apart from their mother tree. The seeds do not contain chlorophyll for photosynthesis. Therefore, there isn't any source of energy available for germination.Hence, plants store nutrients in the seed itself to aid in the development of the embryo.As a food – The starch in the cereal crops can be consumed by humans and animals as food. Ex: Whole wheat flour is used in the bakery industry, Barley endosperm is used in the beer production. Nutritional value of wheat



	Carb./g	Protein/g	Fat/g	Fiber/g	Iron (% daily req.)	Others
Bran	63	16	3	43	59	vitamin Bs
Endosperm	79	7	0	4	7	
Germ	52	23	10	14	35	vitamin Bs omega-3/6 lipids

Nutritional Value (per 100g)

- Some endosperms such as endosperms in legume seeds store proteins as nutrients. Oils can also be extracted from endosperms such as coconut oil, corn oil, sunflower oil, etc.

  20.a. Development of embryo in capsellabursapastoris:

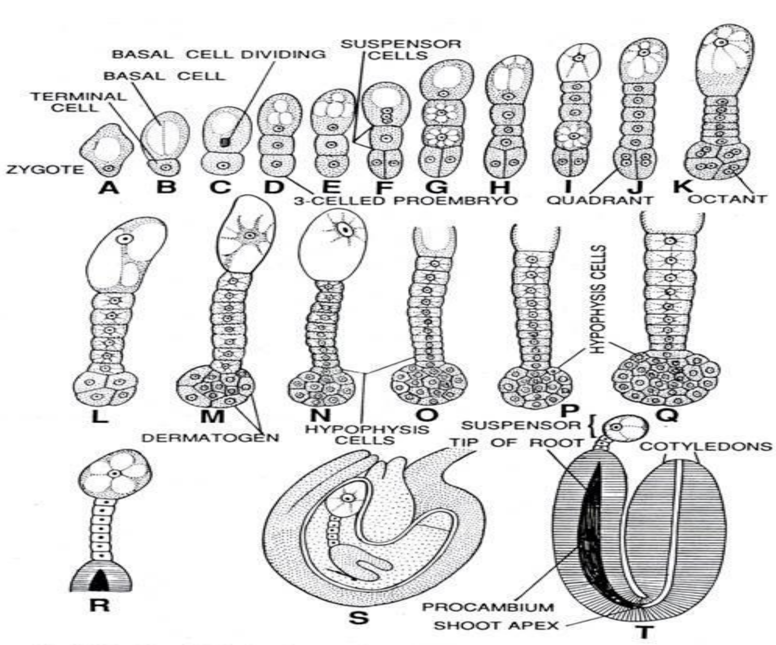


Fig. 46.42. Stages in the development of a typical dicot embryo in *Capsella bursa-pastoris.*

- For the first time Hanstein (1870) worked out the details of the development of embryo in Capsella bursa- pastoris, a member of Crucifeae.The oospore divides transversely forming two cells, a terminal cell and basal cell. The cell towards the micropylar end of the embryo sac is the suspensor cell (i.e., basal cell) and the other one makes to the embryo .cell (i.e., terminal cell). The terminal cell by subsequent divisions gives rise to the embryo while the basal cell contributes the formation of suspensor.The terminal cell divides by a vertical division forming a 4-celled 1-shaped embryo. In certain plants the basal cell also forms the hypocotyl (i.e., the root end of the embryo) in addition of suspensor. The terminal cells of the four-celled pro-embryo divide vertically at right angle to the first vertical wall forming four cells. Now each of the four cells divides transversely forming the octant stage (8-celled) of the embryo.The four cells next to the suspensor are termed the hypo-basal or posterior octants while the remaining four cells make the epibasal or anterior octants. The epibasal octants give rise to plumule and the cotyledons, whereas the hybobasal octants give rise to the hypocotyl with the exception of its tip. Now all the eight cells of the octant divide periclinally forming outer and inner cells.The outer cells divide further by anticlinal division forming a peripheral layer of epidermal cells, the dermatogen. The inner cells divide by longitudinal and transverse divisions forming periblem beneath the dermatogen and plerome in the central region. The cells of periblem give rise to the cortex while that of plerome form the stele.At the time of the development of the octant stage of embryo the two basal cells divide transversely forming a 6-10 celled filament, the suspensor which attains its maximum development by the time embryo attains globular stage. The suspensor pushes the embryo cells down into the endosperm.The distal cell of the suspensor is much larger than the other cells and acts as a haustorium. The lowermost cell of the suspensor is known as hypophysis. By further divisions, the hypophysis gives rise to the embryonic root and root cap. With the continuous growth, the embryo becomes heart-shaped which is made up of two primordia of cotyledons. The mature embryo consists of a short axis and two cotyledons. Each cotyledon appears on either side of the hypocotyl.In most of dicotyledons, the general course of embryogenesis is followed as seen in Capsella bursa-pastoris.

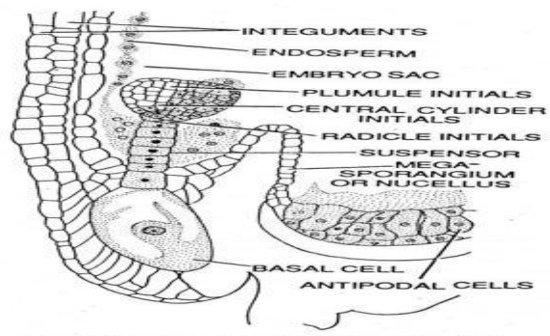


Fig. 46.43. The embryo. L.S. showing differentiation of embryo in *Capsella*.

20.b**monocot embryo development:**

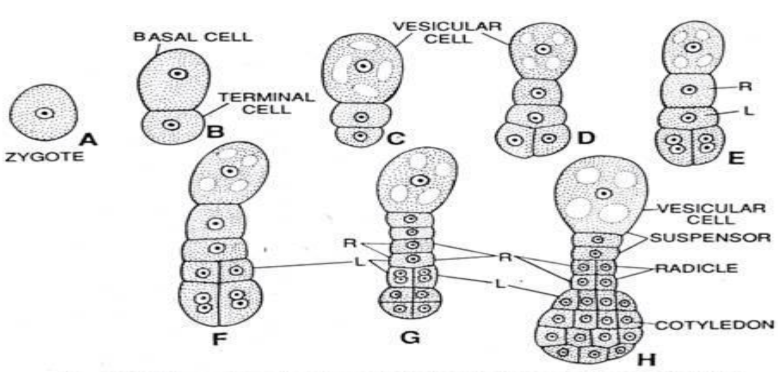


Fig. 46.44. Stages in the development of a typical monocot embryo in *Sagittaria*.

- There is no essential difference between the monocotyledons and the dicotyledons regarding the early cell divisions of the proembryo, but the mature embryos are quite different in two groups. Here the embryogeny of Sagittariasagittifolia has been given as one of the examples.The zygote divides transversely forming the terminal cell and the basal cell. The basal cell, which is the larger and lies towards the micropylar end, does not divide again but becomes transformed directly into a large vesicular cell. The terminal cell divides transversely forming the two cells. of these, the lower cell divides vertically forming a pair of juxtaposed cells, and the middle cell divides transversely into two cells.In the next stage, the two cells once again divide vertically forming quadrants. The cell next to the quadrants also divides vertically and the cell next to the upper vesicular divides several times transversely. The quadrants now divide transversely forming the octants, the eight cells being arranged in two tiers of four cells each. With the result of periclinal division, the dermatogen is formed.Later the periblem and plerome are also differentiated. All these regions, formed from the octants develop into a single terminal cotyledon afterwards. The lowermost cell L of the three-celled suspensor divides vertically to form the plumule or stem tip. The cells R form radicle. The upper 3-6 cells contribute to the formation of suspensor.